DETERMINING YOUTHS' LEVEL OF UNDERSTANDING OF ENVIRONMENTAL CONCEPTS IN THE SAIL TRAINING ENVIRONMENT

by

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ABSTRACT

The aim of this study is to determine youths' level of understanding of selected environmental concepts measured by their verbal responses. With the hypothesis being that youth would be able to observe their environment and note differences and similarities, with a basic understanding of concepts, especially those in the school curriculum but unable to take this further by hypothesising on why differences occur which is more typical of youth of ages 15 years and above. Youth would especially struggle to hypothesise theoretical and abstract concepts as opposed to describing what they observe. It is expected that studies by Piaget will be informative with regards to the cognitive developmental stages in the youth as being categorised into either stages three (concrete-operational) or four (formal-operational).

The study involved nine youths from Christel House, Cape Town, who were selected and assessed on their understanding of four environmental concepts. The crew of the sail ship noted their responses during various lessons offered on board before proceeding with the next.

The results ~~found~~ indicated that the participating youth were able to compare two different observed scenarios as being either similar or different, but were unable to compare theoretical scenarios. Once differences or similarities were established, youth were unable to link factors to hypothesise about why these differences or similarities were occurring, even when prompted or given clues from a crewmember on board the ship. However, the participants were able to hypothesise about the effects of one variable on another when they could actively manipulate a concept to see what might happen under given conditions.

CONTENTS

1: INTRODUCTION

1.1: Literature review

Environmental education (EE) is a broad concept and therefore difficult to define, with many changing definitions over the years, one of the first being by the IUCN (1971), however a more modern definition by Grange (2002) describes EE as being about three main things; which are education about, in and for the environment with changing emphasis on these three aspects over time. Initially the focus was on educating about the environment where subjects like botany taught youth about natural processes, which then moved to educating in the environment, which incorporates teaching methods like experiential learning outdoors and finally EE has become about educating for the environment, which involves developing environmentally aware attitudes leading to social development (Grange 2002).

Capewindjammers Education Trust incorporates all three of these EE aspects in their program by taking youth from the Cape Flats and exposing them to the marine environment where they are taught about the environment and about current environmental problems based on human actions. This is done using experiential learning which has been widely studied with the conclusion that it is a valuable teaching method (Gosenpud 1990). The program also encourages scientific enquiry skills like observation, classification and measurement as outlined by Carey (1989) using various activities like observing and measuring environmental variables based on the five environmental topics of wave formation, distribution of sealife, energy flow in ecosystems, navigation and recycling. The justification for running this program is ultimately to help in developing a society that is environmentally conscious, which sounds ambitious but is not impossible as a study by (Meinhold & Malkus 2005) showed that there is a strong relationship between environmental attitudes and knowledge, and environmental behaviour . However, studies by Hungerford and Volk (1990) show that

for environmental behaviour change, it is not as simple as this, but that behaviour change involves development in what are known as entry level variables, ownership variables and empowerment variables.

However, this program is new and the main problem faced when developing the education curriculum was how to pitch the teaching at the right level for the youth, so that it gives them sufficient stimulation without exceeding their abilities? This is the question that drove this study and requires an understanding of the adolescent mindset and their stages of cognitive development, which will both be discussed below.

Adolescence is the period between childhood and adulthood and is best understood as an interaction between physical, behavioural and social contexts. This transition requires both physical and mental maturation and because of this, adolescence is a sensitive period in development, open to risks and opportunities, and is an area of study that still needs a lot more attention (Dahl 2004 and Steinberg 2005). The area of research that this study intends to further is in cognitive development, specifically in the determination of youths' level of understanding to specific environmental concepts with reference to Piaget's Theory (1970) of cognitive development, discussed below.

The logic of adolescence is complex and distinct from that of children, and constitutes the base from which adult logic develops (Piaget 1970). Piaget's epistemology intended to move away from questions concerning 'what is knowledge?' but rather to illuminate and question assumptions about 'how does knowledge develop?' (Piaget in Smith 1996). Linked to this are three main assumptions that Piaget made, which are also relevant to this study, which are that knowledge occurs at different levels; that these levels are observable; and that there is always a subject whose knowledge can be measured (Smith 1996).

According to Piaget (1970), the stages of cognitive development are as follows: the first two, which are not considered in this study, are sensori-motor intelligence and pre-operational. Sensori-motor intelligence occurs between the ages of 0 – 2 years and is a practical intelligence whereby children learn things towards a specific purpose using the skills currently available to them. Pre-operational follows from this and occurs between 1/2 – 6/7 years and predicts that children do not understand logic and therefore cannot manipulate given information to reach conclusions as they do not understand concepts like reversibility and conservation.

The second two stages are informative with regards to the study, which are concrete-operational and formal-operational. Concrete operational, occurring between the ages of 7/8 – 11/12, predicts that youth gain an understanding of some logical reasoning, but cannot conceptualise hypothetical and abstract ideas. As such, youth solve problems through trial and error using concrete objects and current events. Youth at this level are therefore bound to reality and cannot reason beyond it. Youth also cannot relate two very different objects, but can only compare objects that are similar or neighbouring. Youth at this age are more capable with inductive logic ("converting the outcomes of a specific event to a general principle"). The following stage, termed formal operational occurs after 12 and predicts that reasoning is based on forming relationships or classes. Youth at this age are more capable with deductive logic ("using a general principle to predict the outcomes of a specific event"). Logic is more complete, youth are no longer limited to the manipulation of concrete objects for problem solving, but to reason by stating hypotheses verbally. What is significant about this is that youth now show the ability to deduce the consequences of a hypothesis without needing to visually act them out, showing a formal reasoning process. Youth are no longer bound to reality and can hypothesis on all possible outcomes of an event. This enables youth to begin to theorise and is the first entry point into an adult level of reasoning.

An example provided by Piaget (1970) to help distinguish between stages three and four is that given an experiment to perform, those in stage three will randomly manipulate the material given to them to see what happens, while those in stage four may start with that approach but then find it better to develop a hypothesis and then systematically test each variable in turn.

There are however a few considerations to take into account when using Piaget's theory of cognitive development in research. A study by Lourenço and Machado (1996) summarised the criticism received by Piaget, in which he points out that most criticisms centre on the facts that his work is "conceptually limited, empirically false, or philosophically and epistemologically untenable", meaning that he underestimates the ability of youth, has problems in his methods like not using representative samples and that his predictions are not explanatory enough. Concerns specific to this study are that Piaget's theory underestimates youths' competencies, for example, youth designated as being concrete-operational may exhibit signs of formal-operational reasoning (Lourenço & Machado 1996). This is because, although Piaget set cognitive stages of development as being identified by a set of competencies, he did not suggest that all these factors develop together, otherwise referred to as developmental synchronicity (Lourenço & Machado 1996). Piaget (1970) also stated that although cognitive development always follows the same series of stages, development from one stage to another can occur at varying speeds depending on the individual's characteristics and social environment.

Another consideration is that when analysing youth cognitive development, especially in the formal-operational stage, is that tests must be within the general experience of the youth as it is difficult to hypothesis on things that you have no experience of (Paiget 1970). In other words, a failure of a youth to grasp a concept does not necessarily point to cognitive incompetency but may indicate other underlying factors (Lourenço & Machado 1996). This problem is especially important beyond the concrete-operational stage, when youth begin to specialize in their knowledge, whereas before this

stage, cognitive development follows the same pattern for all youth (Paiget 1970). This means that in any study one must be careful to class a lack of understanding correctly as either being cognitive development or simply divergent specialisations in the individuals (Piaget 1970).

Lastly, another problem is that Piaget's work was based on ideal educational and social situations, making his work difficult to apply universally as the environment in which youth are educated has an effect on the speed at which cognitive development occurs (Piaget 1970). However, Piaget did note the importance of social interactions in cognitive development in his work, although he made a point of not taking this into account when collecting data on cognitive development (Lourenço & Machado 1996). Because of this problem and others discussed above, this study will only use Piaget's theory as a general guide as appose to a hard and fast rule to the different stages of cognitive development.

1.2: Purpose of the study

The study aims to contribute towards the understanding of the cognitive development of youth by increasing the knowledge base of how youth understand selected environmental concepts. The study aims to do this by determining youths' level of understanding of selected environmental concepts based on their ability to verbal express these concepts. From this, youths' level of understanding will be compared against Piaget's (1970) theory of cognitive development, whereby youth are considered against either concrete-operational or formal-operational stages of development. It is hypothesised that youth will struggle with hypothesis testing when thinking about abstract concepts but will be able to hypothesise effectively when able to actively manipulate concepts in which they have had direct experience or in which they are familiar. In terms of Piaget's stages of cognitive development, it is predicted that although youth fall into the formal-operational stage in terms of age, they will show aspects of concrete-operational reasoning.

2: METHODS

2.1: Participants

Participants for this study were students at Christel House School in Ottery, Cape Town, South Africa. The group consisted of nine youth in grade nine, between the ages of fourteen and sixteen, with five girls and four boys. Christel House is a charity organisation that takes youth from townships within 10km of the school, with family incomes not exceeding R2500 per month in households of eight or more (Christel House 2010). Capewindjammers does not select which youth participate on the program, but rather the school selects youth based on how well behaved they are and whether the teacher feels they will benefit from the program offered by Capewindjammers.

2.2 Experimental design

Youths' level of understanding was tested through their ability to verbalise their understanding of specific environmental concepts. Their understanding was classed on two levels as being either a low level of understanding or a high level of understanding, and the classing of these levels was in part guided by Piaget's theory of cognitive development. It is important to note here that the youth were unaware that they were being tested as the study formed part of an environmental education program that the Capewindjammers Education Trust runs for youth from the Cape Flats area.

To test for these two levels of understanding, the participants were presented with a series of problems, covering four specific environmental concepts that required solving. The solving of these problems was designed so that they did not require extensive prior knowledge and any knowledge that was required was provided to them before the start of the test. This was done so that the testing of youths' cognitive level of understanding was not skewed by their lack of theoretical knowledge on the subject matter that the environmental concept was based on.

The study was carried out during a regular environmental education program run by the Capewindjammers Education Trust, which takes nine youth, plus one teaching and four crew on a yacht leaving form the Cape Town harbour. During the program seven environmental topics are covered, of which five were examined in detail in this study. Each environmental topic covered a range of concepts, from which four concepts were chosen to form the base of this study. These environmental topics are listed below with the environmental concepts that are relevant to each:

Environmental concept tested		Environmental topic
1)	Youths' ability to hypothesis on why differences occur in wave formation and sealife distribution	Wave formation Distribution of sea life
2)	Youth's ability to manipulate food webs based on the effects of pollution and resource exploitation	Energy flow in ecosystems
3)	Youths' ability to interpret between charts and their surroundings	Navigation
4)	Youth's ability to understand between how we recycle and how the earth recycles	Recycling

To capture the data, the participants were divided into three groups of two and one group of three. The crewmember working with each group provided the youth with an outline of the environmental topic and the necessary information and then tested their level of understanding of the concepts by asking various questions and getting them do to the various activities and noting the level at which they were able to verbally demonstrate their understanding. The crewmembers impression of youths' level of understanding was noted, however youths' actual verbal expressions were not noted due to the constraining yachting environment which does not encourage taking copious notes at sea. The

crewmember then proceeded with the teaching of the environmental topic and noted any further verbal expressions of their understanding of the topic as the lesson progressed.

At the end of the program, when the youth had left the yacht, all crewmembers had a meeting in which to put together all the information and analyse the youths' level of cognitive understanding of the different environmental concepts based on their verbal expressions and to draw conclusions based on everyone's impressions; the conclusions of these discussions for each environmental concept are provided for in the results section. Section 2.3 provides a short description of the environmental topic, how the environmental concept tested relates to that topic, the expected level of understanding based on Piaget's theory and the accompanying lesson plan.

2.3 Tasks

2.3.1: Concept 1 – Youths' ability to hypothesis on why differences occur in wave formation and sealife distribution

Environmental topic:

How waves form with regard to wind and the effects of natural and man-made landscapes

How environmental concept relates to environmental topic:

Participants were encouraged to analyse the environment and to note differences and hypothesis on why these differences may be occurring based on other environmental and anthropogenic factors. This concept is applied to the environmental topic of wave formation, how waves differ in different areas of the bay and what environmental factors may be influencing this

Expected cognitive understanding:

1. Lower level – Youth distinguish differences but cannot hypothesis why this may be.
2. Higher level – Youth distinguish differences and hypothesis on why this may be

Lesson procedure 1:

1. Introduce the environmental topic by asking the youth if they know how waves are formed. If they do not know then tell them this session is for discovering how waves form like true scientists.
2. In the harbour, measure wind speed, wave/swell height and direction and sea temperature. Ask youth to predict what they think it will be like outside the harbour and why. If they are wrong, do not correct them at this point, let them discover it.
3. Outside the harbour, measure wind speed, wave/swell height and direction and sea temperature.
4. With the youth, take the observations noted in steps 1 and 3 and encourage the youth to hypothesis on why waves form and then why differences in waves occur with reference to all the factors measured.

Environmental topic:

The distribution of 'rocky shore' sealife (muscles, sea anemones, etc) in the harbour compared to the effects of human impacts and use of the environment.

How environmental concept relates to environmental topic:

Youth are encouraged to analyse their environment and to note differences and hypothesis on why these differences may be occurring based on other environmental and anthropogenic factors. This concept is applied to the environmental topic of how environmental and anthropogenic factors may influence the distribution of sea life in harbours.

Expected cognitive understanding:

1. Lower level – Youth distinguish differences but cannot hypothesis why this may be.
2. Higher level – Youth distinguish differences and hypothesis on why this may be

Lesson procedure 2:

1. Introduce the environmental topic by informing the youth that sea life is not the same everywhere as plants and animals are sensitive to environmental conditions and human actions and today they are going to try to work out why sea life differs in two areas of the harbour.
2. Take youth to the yacht mariner and encourage them to analyse sealife richness and abundance and other factors like human activity and water quality. Explain to the youth the basics of the different types of sea life and what environmental disturbances they may be vulnerable to
3. Take youth to the working mariner and encourage them to do the same.
4. Ask youth what the differences are in terms of sealife richness and abundance and other factors like human activity, water quality and to hypothesis on why these differences occurred.

2.3.2: Concept 2 – Youth's ability to manipulate food webs based on the effects of pollution and resource exploitation

Environmental topic:

Studying the energy flow in ecosystems and a basic analysis of what eat what and the effects of pollution and resource exploitation on this balance with the use of food webs.

How environmental concept relates to environmental topic:

Youth are given pieces of information that are related to each other and are encouraged to determine how changing circumstances in one area influences other areas. This is done through the use of a food web and the flow of energy in food webs such that different types of sea life are connected and how pollution and resource exploitation that affect one type of sea life, may have an effect on many others.

Expected cognitive understanding:

1. Lower level – Youth understand the food web and can manipulate the food web to show how affecting one area affects another. When provided with information on how pollution or resource exploitation affects sea life, youth are able to apply this to the food web
2. Higher level – Youth can also apply the food web scenario to theoretical circumstances

Lesson procedure:

1. Introduce the environmental topic by asking the youth if they know what a food web is. Draw up a food web based on the animals and plants found inside and outside the harbour. Encourage youth to demonstrate their understanding of how removing one sealife affects other sealife.
2. Following this, highlight that the main ways in which we interact with the sea are through taking things away from the sea (resource exploitation) or adding things to the sea (pollution). Discuss with the youth examples of resource exploitation and pollution that they may see in and out of the harbour and the effects they have on sealife.
3. Encourage youth to apply this knowledge to the food web and to demonstrate their understanding of how resource exploitation or pollution affecting one type of sealife action can affect other sealife and us.

2.3.3: Concept 3 – Youths' ability to interpret between charts and their surroundings

Environmental topic:

How to navigate on a yacht using marine navigation equipment like charts, GPS's, compasses and various techniques in plotting location and setting courses.

How environmental concept relates to environmental topic:

Youth are encouraged to interpret the same information that they receive in two different forms and to relate them to each other. This was done through the environmental topic of navigation, where youth

were encouraged to observe their surroundings and relate what they see in 3D to what is depicted on charts in 2D. The ability to transfer information enables youth to determine where they are on the chart and to use that knowledge to navigate with the help of various pieces of nautical equipment.

Expected cognitive understanding:

1. Lower level – Youth cannot relate their surroundings to the chart, but are able to orient themselves using landmarks
2. Higher level – Youth are able to relate their surroundings to the chart through simple methods and when the use of more complex nautical equipment is explained to them, can use the appropriate methods to relate their surroundings to the chart

Lesson procedure

1. When outside the harbour, show youth the navigation equipment and ask them to identify them and what they are used for. If they do not know anything about the equipment, tell them what they are called and that they are used for navigation.
2. Get youth to point out where they have come from and how they know that.
3. Using the chart and the compass, get youth to find their general position on the chart and to point the chart so that the north on the chart is pointing to where north actually is.
4. Explain to the youth the theory of a GPS and lines of longitude and latitude in relation to the chart. Using the chart and the GPS, get the youth to point out exactly where they are.

2.3.4: Concept 4 – Youth's ability to understand between how we recycle and how the earth recycles

Environmental topic:

Looking at how the earth cycles resources like water, air and soil which we would struggle to accomplish using technology and comparing this to how we recycle following the three R's of recycling (reduce, reuse and recycle).

How environmental concept relates to environmental topic:

Youths' understandings of two related concepts are determined. Youth are then encouraged to relate these two concepts. The environmental topic used for this is the importance of recycling and draws parallels between how the earth has been constantly recycling air, water and earth and how we recycling things like paper, tin and glass. By drawing these parallels, this topic hopes to enable youth to realise why it is important to recycle; because the earth's resources are not limitless.

Expected cognitive understanding:

1. Lower level – Youth understand the concepts but cannot relate them to each other
2. Higher level – Youth understand the concepts and how they are related to each other

Lesson procedure:

1. Do the earthship activity whereby the youth understand how the earth services our needs, how the capacity to do this is not limitless and how the earth recycles material.
    a. Explain to the youth that we are going on holiday to space and need to decide what we need to take with us for survival. Encourage youth to use a mind map to write down ideas and point out the difference between needs and wants.
    b. Ask youth if earth is anything like a spaceship and whether it is able to provide for our needs and how. Ask youth if they know about the earth cycles and how they work. Discuss the difference between closed cycles (water cycle) and open cycles (rivers) and how the earth is a closed cycle and needs to recycle the same resources over and over.
2. Ask youth what the three R's mean and examples of how we can reduce, re-use and recycle.
3. Ask youth why they think it is important to recycle (save space, save resources, save money), relate how our recycling is similar to the way in which the earth recycles its resources.

3: RESULTS

3.1: Concept 1 – Youths' ability to hypothesis on why differences occur in wave formation and sealife distribution

Distinguishing difference in wind and waves and why

Youth are able to describe differences in environmental variables measured but are unable to hypothesis on why these differences may occur. During the lesson, when the process of wave formation was explained as being influenced by wind and energy, youth were still unable to hypothesis on why differences may occur. Only offer significant leading, whereby youth were encouraged to look at differences in topography and manmade structures as being barriers to wind were youth able to understand that the lay of the land may affect wind dynamics and therefore wave formation. This conclusion only arose after much explanation from the crewmember.

Distinguishing differences in sea life and why

Youth were more familiar with animals than plants but showed an interest in what eats what. Youth were able to describe differences in the richness and abundance of sealife but struggled to identify differences in environmental variables between the two areas in the harbour, although they did notice that the sealife was covered in sediment in the working harbour although they described it as the sealife being dark and dirty. Following this, youth were unable to hypothesis on why differences in sealife distribution may occur based on what they had seen in the two areas of the harbour. Only after repeating to the youth environmental variables and sealife responses directly responsible for the differences, were youth able to understand what may be leading to these differences. However, youth were still unable to verbalise this through forming hypothesis. With enough prompting however, youth did provide hypothesis, but which were didn't match the evidence, but were just random statements.

3.2: Concept 2 – Youth's ability to manipulate food webs based on the effects of pollution and resource exploitation

Youth know what food webs are from school biology and show a good understanding of how affecting one part of the food web affects another part of the food web by explaining that these plants and animals are dependent on each other, shown by the lines that connect them. When given the different types of resource exploitation and pollution, youth were able to think for themselves about the effects this may have on sealife and showed a good understanding of what ways these factors may affect sealife. When given the effects of resource exploitation and pollution on specific sealife shown in the food web, youth were able to use this information and interpret the food web to see what other types of sealife were affected.

3.3: Concept 3 – Youths' ability to interpret between charts and their surroundings

Youth are able to navigate intuitively without using charts, based on familiar landmarks to orient themselves. When asked to use the chart, youth struggled to point out their general position on the chart and point the chart so that it reflected the yacht's point of view relative to the environment without some help on the basics of chart work like interpreting contour lines, finding north and other applicable symbols. Although youth were familiar with charts and other navigational equipment, like compasses and GPSs, they did not show an understanding of the more technical aspects of chart work, like using lines of longitude and latitude to find position and the arrangement of satellites in space to give these exact coordinates, but they recognised the similarity between the hardcopy and electronic charts that were on board the yacht. Of the navigational equipment, youth showed a greater understanding of the chart and compass than of the GPS, and found it especially hard to understand how satellites in space send data about the world to the GPS unit.

3.4: Concept 4 – Youth's ability to understand between how we recycle and how the earth recycles

Youth understand the concept of earth cycles, although they are more familiar with the water and air cycles than the soil cycle. Youth were also able to relate the deduce from the earthship activity that the earth has been reusing the same resources over and over and it would be near impossible for us to do that in space with the technology we have available to us. With the recycling, youth were familiar with the three R's, especially the recycling R, and many knew what they stood for. However, except for recycle, few could give examples of how to reduce and reuse, although part of the problem was a language barrier, where youth did not know what the word meant. In relating the two themes, youth could not grasp the concept that the way the earth recycles is the same as the way we recycle, they could not link the fact that we take a material like glass and make it back into a bottle in the same way that the earth takes something like CO_2 which we breathed out and to turn it back into O_2.

4: DISCUSSION

4.1: Overall impression of youths' level of understanding

Following crew discussions, the general consensus is that youths' ability to verbalise their understanding of concepts was consistent for all groups, no individual appeared to understand more than another except in the case when some did not respond to questions at all and so were considered to not understand the concept being discussed. From this it has been assumed that the issues being discussed here are not due to divergent specialisations in skills at the individual level, but rather the group's level of cognitive development (Paget 1970). In terms of the problem of lack of knowledge affecting measures of cognitive development, youth are provided with all the information they need to complete the task without requiring previous knowledge, except that which would come through cognitive development. This means that a youth's level of understanding, based on their verbal offering, is a reflection of their cognitive development, not their level of general knowledge.

The youths' level of understanding of specific environmental concepts will now be considered in three main groupings; which are the ability to compare differences or similarities in observable versus theoretical scenarios, looking at concepts 1 and 4; youths' ability to hypothesis on observable versus theoretical scenarios, looking at concepts 1 and 2; finally the discussion will touch on youths' ability in interpreting between charts and their surroundings. These first two groupings will then be interpreted with regards to Piaget's theory of cognitive development.

It appears that youth were very good at comparing two different visible factors, as they were quickly able to identify factors like the distribution of sea life and the actions of waves and wind as being either similar or different, such that youth identified that sealife in the yachting harbour was more abundant and diverse than in the working harbour and that water quality in terms of clarity and floating litter was

better in the yachting harbour than in the working harbour. However, youth were unable to compare theoretical scenarios like the way we recycle and the way the earth 'recycles' as being either similar or different, in that youth could not even begin to see how these two could be compared even though they understood earth cycles like the water cycle and they understood examples of recycling like the life cycle of a coke bottle.

In terms of formulating hypothesis, youth were much more capable of this when the scenario in question could be directly manipulated, but struggled when hypothesising on theoretical scenarios. What was seen was that when considering the effects of pollution and resource exploitation on sealife, youth were able to hypothesis on the outcomes by directly manipulating the food web drawn out before them. However, when hypothesising on why sealife observed in the harbour differed, they were unable to link observed differences in water pollution and other related human impacts with differences in sealife abundance and richness, even when given prompts and clues from a crew member.

Lastly, youth had an intuitive understanding of navigation in that they could orient themselves, and determine the path of the yacht without needing to use charts or other nautical equipment. However, when introduced to navigation, they struggled with the use of charts, compasses and GPSs, but with enough explanation, were able to navigate. This shows that their lack of understanding is more probably related to their lack of exposure to these types of equipment and not due to their lacking the ability to understand the concept of interpreting between charts and their surroundings.

4.2: Relationships between their level of understanding and cognitive development

4.2.1: Being able to relate two observable scenarios versus two theoretical scenarios

What was found was that youth were very capable of relating objects to each other, but struggled in relating theories. Such that for the environmental topics of distribution of sealife and wave formation

youth were able to distinguish differences in environmental variables quite easily. However, with the environmental topic of recycling, although youth understood the two concepts of how we recycle and how the earth recycles, they were unable to see how the two related to each other. This again relates to the two cognitive development stages, three and four, outlined by Piaget (1970), which dictate that for concrete-operational, youth are able to reason using real objects but that only in the formal-operational stage are they able to reason with theoretical objects, which would explain why they are able to relate things in their environment, which they can experience directly, but struggle in relating theoretical concepts.

4.2.2: Being able to hypothesis on scenarios that may be observed or manipulated versus theoretical scenarios

What was found was that youths' level of understanding of two environmental concepts shows youths' cognitive development has aspects of both the third and fourth stages as outlined by Piaget (1970). In two environmental topics, wave formation and distribution of sealife, youth were able to distinguish differences in multiple variables, but were unable to engage in the scientific process of hypothesising, which would require linking variable to determine why differences in wave formation or sealife occur. However, in the environmental topic, energy flow in ecosystems, youth understood the concept of food webs and were able to hypothesis on the effects that resource exploitation and pollution may have on ecosystems through the use of the food web. From this, I conclude that youth are able to relate things when they are presented in front of them in a pictorial form and explained (energy flow in ecosystems environmental topic), but cannot go to two different geographical areas and compare them when they cannot see them together as a unit and directly manipulate them. This means youth are operating at a concrete level which Piaget (1970) predicts for youth aged of 11 / 12 years old.

These observations are comparable to Piaget's (1970) stages of cognitive development, where in stage three youth are able to compare neighbours but do not have the capacity to fully relate two elements to each other especially when they cannot be directly manipulated, but in stage four, youth are able to theorise and can therefore consider two things together in the hypothetical sense, without having to manipulate them directly. This is why I think the youth were able to verbally express their understanding of the food web activity because it's an object they could directly manipulate by drawing the food web and actively eliminating areas by erasing them, but in the sea life and wave formation activity, direct manipulation was not possible, only observation and from there, theorising on possible explanations without being able to see those possibilities played out before them. These two activities would indicate that youth are at stage three.

4.3: Summary and conclusions

It appears that youth show a level of understanding that is more related to Piaget's third, concrete-operational stage of cognitive development which is predicted for youth aged 7/8 – 11/12 years than for youth in grade 9 who are around the age of 15 years, which would be associated with Piaget's fourth, formal-operational stage of development. This is shown by the fact that youth are capable of reasoning with scenarios that can be observed or manipulated but struggle with theoretical scenarios. However, the research does not extend far enough to give a definite reason for this outcome, however, a possible reason, also suggested by Piaget (1970), is the effect of social backgrounds which have the ability to slow cognitive development.

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